Data measured during tests of a centrifugal pump at 3500 rpm are given in the table below:

Parameter	Inlet Section	Outlet Section
gage pressure, p [kPa]	95.2	412
elevation above datum, z [m]	1.25	2.75
avg speed of flow, V [m/s]	2.35	3.62

The working fluid is water. The flow rate is 11.5 m^3/hr and the torque applied to the pump shaft is 3.68 N·m. Evaluate the head rise across the pump, the hydraulic power input to the fluid, and the pump efficiency. If the electric motor efficiency is 85%, calculate the electric power requirement.

SOLUTION:

First determine the total heads at the inlet and outlet to the pump. The total head is given by:

$$H = \frac{p}{\rho g} + \alpha \frac{\bar{V}^2}{2g} + z$$

Using the given data (and noting that $D = [Q/(\pi/4 V)]^{1/2}$ and $\mathrm{Re} = VD/\nu$ so that $\mathrm{Re}_{inlet} = 9.78e4$ and $\mathrm{Re}_{outlet} = 1.21e5 \Rightarrow \alpha_{inlet} \approx \alpha_{outlet} \approx 1$) and using absolute pressures when calculating the head:

H_{inlet} = 21.6 m

H_{outlet} = 55.7 m

$\boxed{\Delta H = 34.1 \text{ m}}$

The hydraulic power input to the fluid is given by:

$$\dot{W}_{fluid} = \dot{m} g \left(H_{outlet} - H_{inlet} \right)$$

$\boxed{\dot{W}_{fluid} = 1.07 \text{ kW}}$

The power required to drive the pump is:

$$\dot{W}_{shaft} = T\omega$$

$\dot{W}_{shaft}$ = 1.35 kW

The efficiency of the pump is given by:

$$\eta_{pump} = \frac{\dot{W}_{fluid}}{\dot{W}_{shaft}}$$

$\boxed{\eta_{pump} = 79.4\%}$

The electric power required is:

$$\dot{W}_{\substack{\text{required} \\ \text{for motor}}} = \dot{W}_{shaft} \Big/ \eta_{motor}$$

$\boxed{\dot{W}_{\substack{\text{required} \\ \text{for motor}}} = 1.59 \text{ kW}}$